REQUEST FOR ACTION (RFA) RESPONSE

GLAST LAT Project
Calorimeter Peer Review **17 – 18 March 2003**

Action Item:	CAL – 007
Presentation Section:	Mechanical
Submitted by:	Jim Ryan

Request: Strength Qual - Lay out plan for strength qualification of "flight" composite structure.

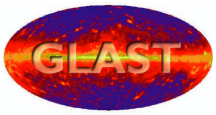
Reason / Comment: Process changes are being made from EM to "flight" composite structure. Composite structures are very process dependent. It is my understanding that flight structures will not be tested at 1.25 times maximum flight predicted loads.

Response: 3 May 2003

Please see attached verification plan for the flight structure, LAT-SS-02052-01 (GLAST-LLR-SP-078). The strength qualification of the composite structure is addressed in this document.

Strength qualification of the flight composite structure will involve sine sweep, sine burst, and random vibration of the structure built up with its aluminum piece parts are mass simulators representing the CDEs.

Note, the referenced document needs to be updated to the newly approved lower test levels. The qual random vibration test levels have been reduced from 0.04 g^2/Hz down to 0.02 g^2/Hz

Document Projet / Project Document			
	*GLAST LAT CAL Mechanical Structure*	Ref :	GLAST-LLR-SP-078
		Issue :	draft
		Date :	April 17, 2003
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Flight Structure Verification Plan

LAT reference : LAT-SS-02052-01

Change History log

Ind.	Date	Modifications	Prepared	Checked	PA Approval	Project Approval
draft	April 17, 2003		P.Prat		S. Le Quellec	O. Ferreira

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List of Acronyms

AIT	Assemblage, Integration et Test
AFEE	Analog Front-End Electronic
CAL	sous-système calorimètre du LAT
CDE	Crystal-Diode Element
CEA	Commissariat à l'Energie Atomique
CNES	Centre National d'Etudes Spatiales
DCI	Dossier de Contrôle des Interfaces
DCF	Dossier de Fabrication et de Contrôle
DD	Dossier de Définition
DJD	Dossier Justificatif de la Définition
EM	Engineering Model
EMC	Electromagnetic Compatibility
EGSE	Electric Ground Support Equipment
GLAST	Gamma-Ray Large Area Space Telescope
LAT	Large Area Telescope
LLR	Laboratoire Leprince-Ringuet
N/A	Not Applicable
NRL	Naval Research Laboratory
PCB	Printed Circuit Board
SLAC	Stanford Linear Accelerator Center
STB	Spécification Technique de Besoin
TBR	To Be Resolved
TBD	To Be Defined
TBC	To Be Confirmed

1 INTRODUCTION

1.1 OVERVIEW

GLAST is a next generation high energy gamma-ray observatory designed for making observations of celestial gamma-ray sources in the energy band extending from 20 MeV to more than 300 GeV. It follows in the footsteps of the Compton Gamma Ray Observatory EGRET experiment, which was operational between 1991-1999. The GLAST Mission is part of NASA's Office of Space and Science Strategic Plan, with launch anticipated in 2006. The principal instrument of the GLAST mission is the Large Area Telescope (LAT) that is being developed jointly by NASA and the US Dept. of Energy (DOE) and is supported by an international collaboration of 26 institutions lead by Stanford University.
The GLAST LAT is a high-energy pair conversion telescope that has been under development for over 7 years with support from NASA, DOE and international partners. It consists of a precision converter-tracker (TKR), CsI hodoscopic calorimeter (CAL), plastic scintillator anticoincidence system (ACD) and a data acquisition system (T&DF).

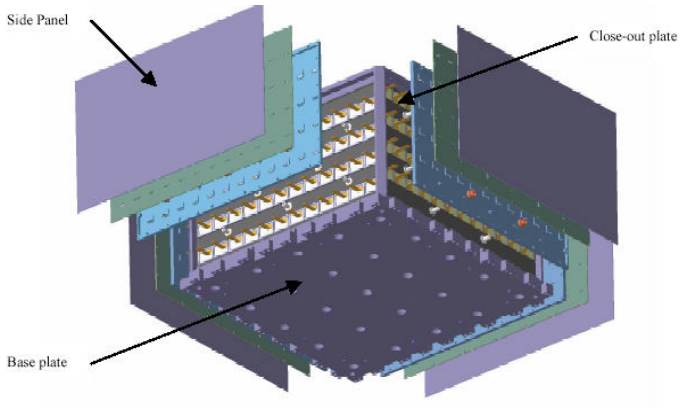
The GLAST LAT Calorimeter (CAL) subsystem consists of 16 identical modules arranged in a 4 × 4 array that is defined by the LAT support grid structure. Each CAL module is made of:

- 1 mechanical structure,
- 96 CDE (CsI crystal, wrapped in reflective material and equipped with dual PIN photodiodes), arranged horizontally in 8 layers of 12 crystals each. Each layer is aligned 90° with respect to its neighbors, forming an x-y array,
- 4 electronics cards for signal processing.

LLR participation in the GLAST program consists in the development and delivery of the CAL mechanical structure (see figure below), which is composed of:

- a carbon composite structure on which are attached Titanium inserts,
- an aluminum baseplate which presents the structural I/F to the LAT grid structure,
- an aluminum top frame,
- 4 aluminum close-out plates,
- 4 aluminum side panels that provide shielding.

Figure 1-1: Exploded view of CAL mechanical structure



1.2 SCOPE OF THE DOCUMENT

The scope of this document illustrates the various testing phases achieved or supervised by IN2P3 in which each CAL structure shall undergo in order to be considered ready for delivering at NRL. Structural Environment Performance requirements are verified by a combination of testing, inspection and control at the qualification test level on FM structures.

1.3 APPLICABLE DOCUMENTS

All Applicable Documents are listed in the CIDL (GLAST-LLR-LI-029).

1.4 REFERENCE DOCUMENTS

	Title	*Reference*
RD01	Procédure de test d'environnement mécanique des structures de vol	GLAST-LLR-SP-079
RD02	Procédure de métrologie des structures de vol	GLAST-LLR-SP-072
RD03	Spécification de test non destructif des structures de vol	GLAST-LLR-SP-074
RD04	Procédure de contrôle visuel des structures de vol	GLAST-LLR-SP-081
RD05	Composite structure plan	GLT-LLT-00-02
RD06	CAL Mechanical Structure Product Assurance Plan	GLAST-LLR-PL-026
RD07	CAL Mechanical MAIV Plan	GLAST-LLR-PL-015

2 VERIFICATION MATRIX

The general approach for attaining the verification program objectives is described in LAT-SS-01345-0 (CAL Verification & Environmental Test Plan) as follows:
a) The Calorimeter Modules shall be verified by test at the qualification or acceptance test levels. Several models of Calorimeter Modules shall be built and tested. Each subsequent series shall leverage manufacturability and performance characteristics from the previous model towards the goal of flight production.
b) Verification and test shall begin at the subsystem or component level as required/applicable, prior to delivery for integration to the LAT.
c) Calorimeter Module substems shall receive both functional and environmental testing at the qualification or acceptance levels. Flight modules shall either be qualified by similarity or tested to the acceptance levels.

The following verifications will be achieved on SM, FSM, FMA, FMB and FM1 to FM16 CAL composite structures under the responsibility of IN2P3 prior to delivery to NRL:

Model	Visual Control	Metrology	Structural Environmental Test	Non Destructive Control
SM	I	M	TQ	-
FSM	I	M	-	-
FMA	I	M	TQ	T
FMB	I	M	TQ	-
FM1	I	M	TQ	-
FM2	I	M	TQ	-
FM3	I	M	TQ	-
FM4	I	M	TQ	T
FM5	I	M	TQ	-
FM6	I	M	TQ	-
FM7	I	M	TQ	-
FM8	I	M	TQ	-
FM9	I	M	TQ	-
FM10	I	M	TQ	T
FM11	I	M	TQ	-
FM12	I	M	TQ	-
FM13	I	M	TQ	-
FM14	I	M	TQ	-
FM15	I	M	TQ	-
FM16	I	M	TQ	T

I: Inspection M: Measurements TQ: Test, Qual level T: Test

Table 2-1: Verification matrix

The structural environment tests shall be achieved on each CAL flight structure at qualification level as required on composite material parts. Structural environment tests will include sine burst test, random test and survey test. Thermal cycling is not required at CAL structure level.

3 TEST SEQUENCES

The verification matrix (table 2.1) summarizes the tests, inspections and controls achieved on each FM structure. 2 tests sequences will be applied according to the models:

- a **complete test sequence** achieved on models FMA, FM4, FM10 and FM16
- a **reduced test sequence** achieved on models SM, FMB, FM1, FM2, FM3, FM5, FM6, FM7, FM8, FM9, FM11, FM12, FM13, FM14 and FM15
- a **control sequence** achieved on model FSM

The following figures show the 3 types of verification sequences:

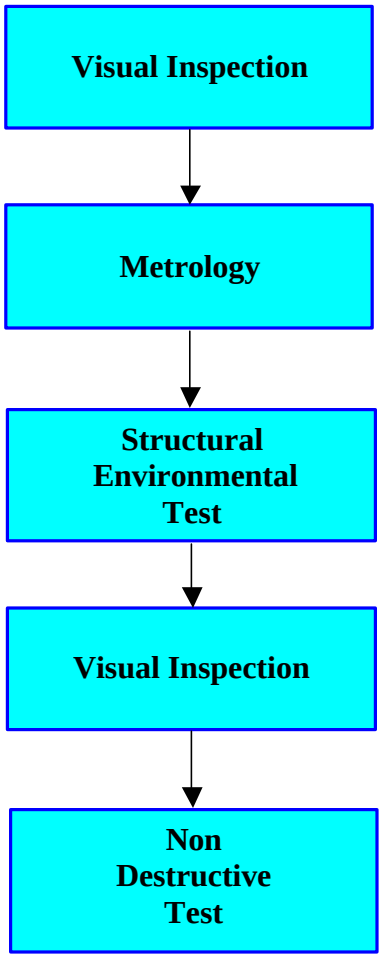


Figure 3-1: Complete test flow

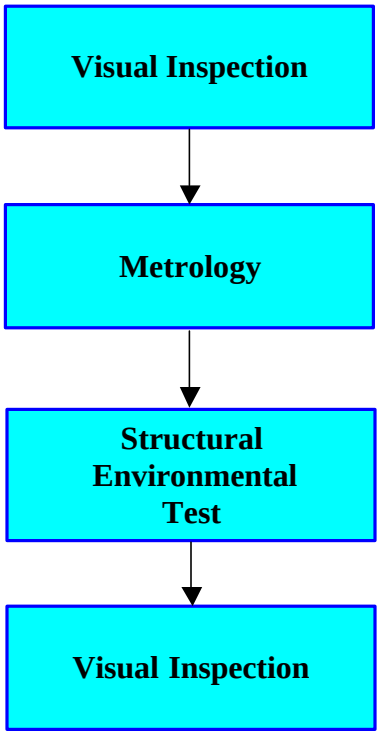


Figure 3-2: Reduced test flow

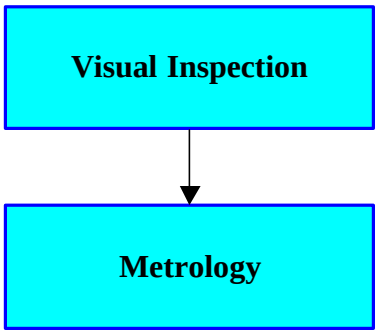


Figure 3-3: Control test flow

4 GENERAL REQUIREMENTS

4.1 TEST FACILITY REQUIREMENTS

The facilities and test equipment used in verifying the Calorimeter components and system modules shall be capable of producing and maintaining the test conditions with the test specimen installed and operating or not operating as appropriate. In any major test, facility performance shall be verified prior to the test either by review of its performance during a test that occurred a short time earlier or by conducting a test with a substitute test item.

4.2 CONTAMINATION CONTROL REQUIREMENTS

Contamination control of flight and test hardware during the verification program shall be in accordance with the requirements of the Calorimeter, Tracker, and Data Acquisition Contamination Control Plan; [LAT-MD-00228-01].
Specific requirements for particulate or molecular contamination control shall be included in component/subsystem specifications and test plans and procedures.

4.3 WAIVERS AND EXCEPTION

A waiver or exception to the requirements of this specification shall be granted only by direction or concurrence of the Calorimeter Project Manager or his authorized representative through the Configuration Management process.

4.4 FAILURE AND RETEST REQUIREMENTS

When a failure (non-conformance or trend indicating that an out-of-spec condition will result) occurs, determination shall be made as to the feasibility and value of continuing the test to completion. If corrective action is taken, the test shall be repeated to the extent necessary to demonstrate that the test item's reliability and verify satisfactory performance.
If during a test sequence a test item is operated in excess of design parameters and becomes unsuitable for further testing, a spare may be substituted. However, if the substitution affects the significance of test results, the test during which the item was replaced and any previously completed tests that are affected shall be repeated to the extent necessary to demonstrate satisfactory performance.
Failures shall be recorded and tracked as a problem record on a Non-Conformance Report.

4.5 TEST READINESS REVIEW (TRR)

All CAL structure module tests shall be preceded by a test readiness review wherein the readiness of the test article, facilities, test equipment, and procedures are verified.
This Review is described in GLAST-LLR-PL-025 (CAL Mechanical Structure PA Plan - §9.4.3).

4.6 POST TEST REVIEW (PTR)

Following the tests of the Calorimeter Structures, formal reviews shall be held wherein test data are reviewed to determine conformance with the test requirements prior to delivering any flight level deliverables to NRL. Test reports are required for all CAL structure.
This Review is described in GLAST-LLR-PL-025 (CAL Mechanical Structure PA Plan - §9.4.3).

4.7 DOCUMENTATION REQUIREMENTS

The following procedures and reports are required to conduct the verification program and document the results.

4.7.1 *Test Procedure and Supporting Analysis*

All prototype and flight hardware shall be verified and tested using procedures approved by the Calorimeter Project. Test procedures shall be prepared to describe the activities required by this verification specification.
The content of test procedures is described in GLAST-LLR-PL-026 (CAL Mechanical Structure Product Assurance Plan - §9.4.1) and GLAST-LLR-PL-015 (CAL Mechanical MAIV Plan - §5.3.4.1).

4.7.2 *Test Report*

Test reports shall be prepared after the completion of test activities for the Calorimeter modules. The content of test reports is described in GLAST-LLR-PL-026 (CAL Mechanical Structure Product Assurance Plan – 9.4.4) and GLAST-LLR-PL-015 (CAL Mechanical MAIV Plan - §5.3.4.2).

5 TESTING REQUIREMENTS

The following tests, demonstrations, and supplemental analyses are required for Calorimeter composite structure. Where items are indicated on a selective basis, the verification test matrix (Table 2-1 of this document) shows applicability.

- Mass Properties; (measurement)
- Interface Verification Test
- Minimum Modal Frequency Verification Test; (Sine Sweep)
- Sine Burst Vibration Strength Test
- Random Vibration Test
- Visual inspection
- Nondestructive control

The above tests and appropriate analyses and inspections, shall be conducted to provide assurance that the mechanical structure parts meet specified, environmental, design and interface requirements.

5.1 STRUCTURAL TESTS

The metrology procedure (RD01) shall define in detail the process of the structural test. Hereafter are defined the structural tests requirements.

5.1.1 Sinus Sweep

The CAL FM structure shall undergo a sine sweep in order to determine the modal frequencies on 3 perpendicular axis (x, y and z) before and after the quasi-static acceleration test:

Fréquencies	Level	Sweep rate
10-2000 Hz	0,2 gpk	2 oct/mn

Table 5-1 : Sine sweep levels

5.1.2 Quasi-static Acceleration

The CAL FM structure shall undergo a quasi-static acceleration test in using the sine burst method with the following levels on the 3 axis (x, y and z):

Axis	Fréquency fc	Acceleration level A	Duration Td	Cycle
Axe transverse (Z)	25 Hz	± 6.8 $g's_{0\text{-}pk}$	18 cycles (720 ms)	1
Axe de poussée (X,Y)	25 Hz	± 8.5 $g's_{0\text{-}pk}$	18 cycles (720 ms)	1

Table 5-2 : Static acceleration levels

5 peaks shall be above the acceleration level. The time evolution of the sine burst is given by:

$Ac(t) = 1,15 * A * \sin(2*p*fc*t) * \sin(p*t/Td)$

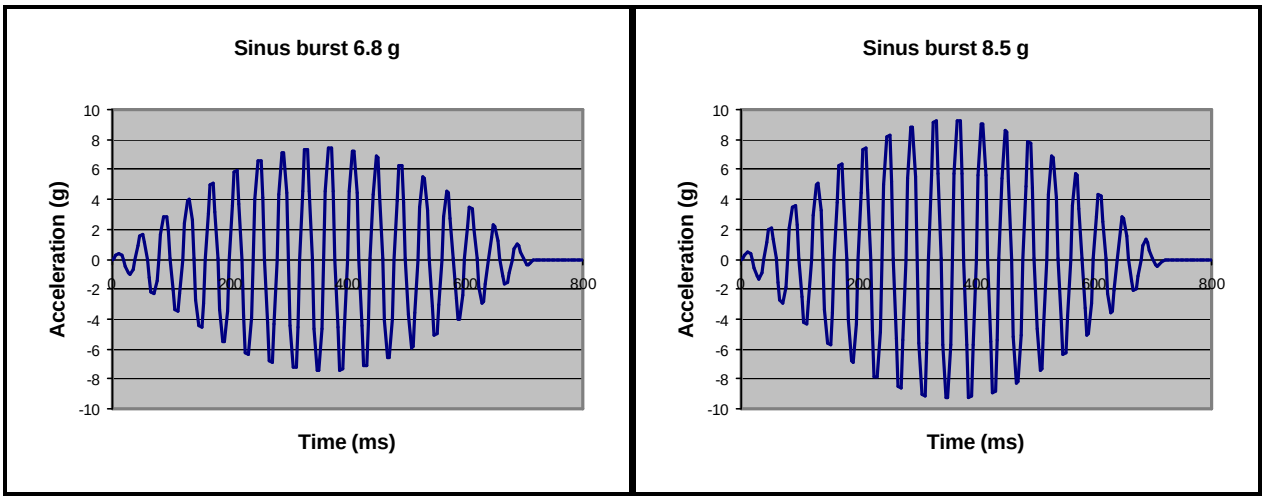


Figure 5-1 : Sine-burst

5.1.3 *Random Vibration Test*

The CAL FM structures shall undergo a random vibration test with the following levels on the 3 axis (x, y and z) :

Frequency	Acceleration Spectral Density (ASD)
20 Hz	0,01 g²/Hz
20 – 50 Hz	4,5544 dB/oct
50 – 800 Hz	0,04 g²/Hz
800 – 200 Hz	-4,5544 g²/Hz
2000 Hz	0,01 g²/Hz

Table 5-3 : Random vibration levels

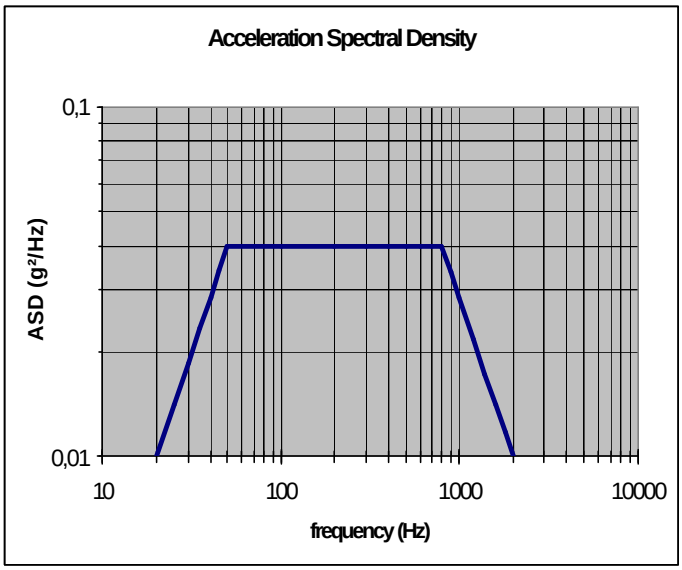


Figure 5-2 : Random vibration spectrum

Test duration per axis : 2 mn

5.2 METROLOGY

The metrology procedure (RD02) shall define in detail the process of the structure dimension measurements. Hereafter are defined the dimensions requirements.

The verified dimensions are :
- Width of the structure between the shoulders of the opposite face : C1
- Height of the structure : C2
- Planeïty, parallelism and straightness of th 6 faces
- Cell height: C3
- Cell width: C4

Dimensions		Specification	
		Min	Max
C1-1	Face X^+ / X^-	340.6	341
C1-2	Face Y^+ / Y^-	340.6	341

Table 5-4 : Structure width requirements

Dimensions	Specification	
	Min	Max
C2	176.8	177.2

Table 5-5 : Structure height requirements

Dimensions	Specification	
	Min	Max
C3	20.45	20.55
C4	27.30	27.40

Table 5-6 : Cell dimension requirements

Specification of the planeïty : ≤ 0,40 mm
Specification of the parallelism ≤ 0,40 mm (TBC)
Specification the straightness ≤ 0,40 mm (TBC)

The dimensions of 10 cells per faces will be verified on opposite sides. The locations of the verified cells are shown on the following page.

Couches	1	2	3	4	5	6	7	8	9	10	11	12
1	Cell 1-1	Cell 1-2	Cell 1-3	Cell 1-4	Cell 1-5	Cell 1-6	Cell 1-7	Cell 1-8	Cell 1-9	Cell 1-10	Cell 1-11	Cell 1-12
			o			o				o		
3	Cell 3-1	Cell 3-2	Cell 3-3	Cell 3-4	Cell 3-5	Cell 3-6	Cell 3-7	Cell 3-8	Cell 3-9	Cell 3-10	Cell 3-11	Cell 3-12
					o				o			
5	Cell 5-1	Cell 5-2	Cell 5-3	Cell 5-4	Cell 5-5	Cell 5-6	Cell 5-7	Cell 5-8	Cell 5-9	Cell 5-10	Cell 5-11	Cell 5-12
			o			o				o		
7	Cell 7-1	Cell 7-2	Cell 7-3	Cell 7-4	Cell 7-5	Cell 7-6	Cell 7-7	Cell 7-8	Cell 7-9	Cell 7-10	Cell 7-11	Cell 7-12
					o				o			

Figure 5-3 : Cell locations on the X+ face of the composite structure

Couches	1	2	3	4	5	6	7	8	9	10	11	12
					o				o			
2	Cell 2-1	Cell 2-2	Cell 2-3	Cell 2-4	Cell 2-5	Cell 2-6	Cell 2-7	Cell 2-8	Cell 2-9	Cell 2-10	Cell 2-11	Cell 2-12
			o			o				o		
4	Cell 4-1	Cell 4-2	Cell 4-3	Cell 4-4	Cell 4-5	Cell 4-6	Cell 4-7	Cell 4-8	Cell 4-9	Cell 4-10	Cell 4-11	Cell 4-12
					o				o			
6	Cell 6-1	Cell 6-2	Cell 6-3	Cell 6-4	Cell 6-5	Cell 6-6	Cell 6-7	Cell 6-8	Cell 6-9	Cell 6-10	Cell 6-11	Cell 6-12
			o			o				o		
8	Cell 8-1	Cell 8-2	Cell 8-3	Cell 8-4	Cell 8-5	Cell 8-6	Cell 8-7	Cell 8-8	Cell 8-9	Cell 8-10	Cell 8-11	Cell 8-12

Figure 5-4 : Cell locations on the Y+ face of the composite structure

5.3 NON-DESTRUCTIVE TEST

The nondestructive test will be achieved by Computed X-Ray Tomography (TBC) at sub-contractor facilities.
The nondestructive test specification (RD03) shall describe the process of control of the structure by a Computed X-Ray Tomography.

The specification shall define the area inspected and criteria of acceptance.

5.4 VISUAL INSPECTION

The visual inspection procedure (RD04) shall describe the process of inspection of the structure.

The procedure shall define the area inspected and criteria of acceptance.